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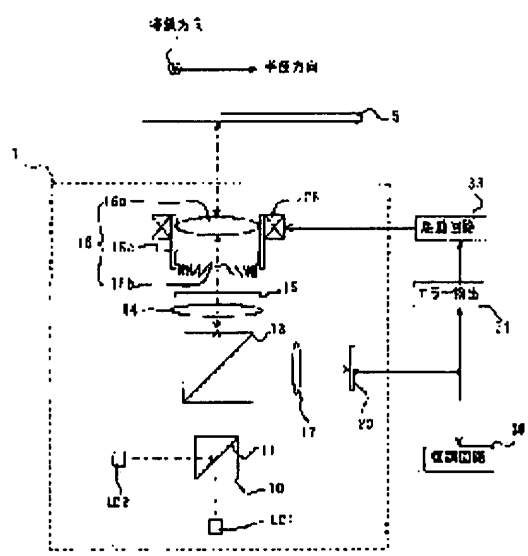
(54) OPTICAL PICKUP

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical pickup suitable for miniaturization and capable of recording and reproduction to the optical disk or recording surface of different corresponding wavelengths.



SOLUTION: This optical pickup is provided with a first light source for emitting a first light beam having a first wavelength, a second light source for emitting a second light beam having a second wavelength longer than the first wavelength, a condensing lens for converging the first and second light beams to the information recording surface of a recording medium and a diffraction optical element arranged in an optical path from the first and second optical sources to the condensing lens. The condensing lens converges the diffracted light beam of a first diffraction order of the first light beam from the diffraction optical element as information reading light or information recording light and converges the diffracted light beam of a second diffraction order lower than the first diffraction order of the second light beam from the diffraction optical element as the information reading light or the information recording light.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical pickup which makes possible compatibility from the optical disk with which response wavelength differs to DVD and HD-DVD using a laser light source of especially different wavelength about the optical system of the optical pickup in the optical recording regenerative apparatus which carries out record playback of the information.
[0002]
[Description of the Prior Art] There is an optical disk player which reads recording information and can do it from optical disks, such as an optical recording medium (digital video disc), for example, DVD etc., in the account rec/play student equipment of optical. Although DVD with a capacity of 4.7GB is introduced into the commercial scene, the demand of still higher-density package media is strong, and the examination is progressing. Short-wavelength-izing of the light source and a raise in NA of an objective lens which are used as known well are effective in improvement in recording density. About short-wavelength-izing, research of the semiconductor laser of the short wavelength which used the GaN substrate as the base shows progress, and utilization has it in near level. The wavelength of the laser under development is 405nm, and research of about 15GB of high density DVD (HD-DVD) system using this is advanced similarly.
[0003] Then, although the compatible disk player which reads recording information and can do it from DVD and HD-DVD will be called for, a duty of the regeneration system is imposed as naturally DVD being reproducible. It becomes a problem that a two-layer disk cannot be read among DVD disks by the laser of short wavelength here. Since the reflection factor in the short wave Nagamitsu beam of the middle class of a two-layer disk is low, this is produced. Therefore, in order to realize a compatible disk player, a HD-DVD system needs to carry the laser which emits light in the light beam (only henceforth red) of the red near the wavelength of 650nm in addition to the laser which emits light in the blue light beam near the wavelength of 405nm (only henceforth blue). Conventionally, in DVD, substrate thickness is 0.6mm and the numerical aperture of 635nm - 655nm and an objective lens of response wavelength is about 0.6. In HD-DVD, substrate thickness is 0.6mm and the numerical aperture of 405nm and an objective lens of response wavelength is about 0.6.
[0004] However, it is difficult to condense mostly the light both from which wavelength differs with the conventional single lens for the chromatic aberration which an objective lens has by non-aberration. For this reason, in order to secure the compatibility of DVD and HD-DVD, a certain device is needed.
[0005]
[Problem(s) to be Solved by the Invention] Then, although the approach of changing for every wavelength using an exclusive objective lens can be considered as the implementation approach of the optical pickup for the compatible players of DVD and HD-DVD, since a complicated lens change device is required of that of ****, cost increases and an actuator becomes large about two objective lenses, it is disadvantageous for a miniaturization. Moreover, although how to combine with an objective lens and a collimator lens can be considered as other approaches, since the collimator is fixed to an objective lens,

problems, like it is difficult to maintain the engine performance at the time of migration of an objective lens occur.
[0006] Anyway, in order to secure the compatibility of DVD and HD-DVD, when the optical system of the prism of dedication, a lens, etc. is constituted using two or more light sources, there is an inclination for an optical pickup or the optical whole head to become complicated, and to become large-sized. This invention is made in view of the above-mentioned technical problem, and is to offer the optical pickup which was suitable for the miniaturization in which an account rec/play student is possible to the optical disk or recording surface from which response wavelength differs.
[0007]
[The means for solving invention] The 1st light source to which the optical pickup of this invention carries out outgoing radiation of the 1st light beam which has the 1st wave, The 2nd light source which carries out outgoing radiation of the 2nd light beam which has the 2nd wave longer than the 1st wave, The condenser lens which makes the information recording surface of a record medium condense said 1st and 2nd light beams, It is the optical pickup equipped with the diffracted-light study component arranged in the optical path from said 1st and 2nd light sources to said condenser lens. Said condenser lens About said 1st light beam, the 1st light beam diffracted light of the 1st order of diffraction by said diffracted-light study component is condensed as information reading light or an information record light. About said 2nd light beam, it is characterized by condensing the 2nd light beam diffracted light of the 2nd order of diffraction of a low degree as information reading light or an information record light from said 1st order of diffraction by said diffracted-light study component.
[0008] In the optical pickup of this invention, said diffraction grating is characterized by having a serrate cross section. In the optical pickup of this invention, said diffraction grating is characterized by having a stair-like cross section. In the optical pickup of this invention, as for the absolute value of said 1st order of diffraction of said 1st light beam diffracted light, only 1 is larger than the absolute value of said 2nd order of diffraction of said 2nd light beam diffracted light, and it is characterized by the absolute value of said 2nd order of diffraction of said 2nd light beam diffracted light being one or more.
[0009] In the optical pickup of this invention, when said 1st light beam diffracted light is the secondary diffracted light, or said 2nd light beam diffracted light is the primary diffracted light, when said 1st light beam diffracted light is the 3rd diffracted light, said 2nd light beam diffracted light is characterized by being the secondary diffracted light. In the optical pickup of this invention, the depth of said diffraction grating is characterized by being within the limits of 1.42**0.2 micrometers or 2.40**0.2 micrometers.
[0010] In the optical pickup of this invention, the pitch of said diffraction grating is characterized by being 20 micrometers or more. In the optical pickup of this invention, it is characterized by for said 1st wave being 400nm - 410nm, and said 2nd wave being 630nm - 660nm. In the optical pickup of this invention, said diffracted-light study component has a plano-concave lens, and it is characterized by forming said diffraction grating in the concave surface of a plano-concave lens.
[0011] In the optical pickup of this invention, said diffracted-light study component is a condenser lens and really [said] fabricated, and it is characterized by forming said diffraction grating in the light source side front face of said condenser lens.
[0012]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained, referring to a drawing.
(Optical pickup) Drawing 1 shows the outline of the optical pickup of one gestalt of operation. The optical pickup is equipped with semiconductor laser LD1 for HD-DVD to which the 1st wave carries out outgoing radiation of 400nm - the 410nm of the blue of the short wavelength near 405nm preferably, and semiconductor laser LD2 for DVD which carries out outgoing radiation of the red, the 2nd wave, i.e., the long wavelength desirable 630nm - 660nm for DVD near 650nm, longer than the 1st wave. Semiconductor laser LD1 and LD2 is changed as the object for HD-DVD, and an object for DVD, and is turned on.
[0013] Furthermore, the optical pickup is equipped with the optical-axis joint prism (color composition prism) 10 of the optical-axis joint component for which the optical path of these 1st and 2nd light

beams, i.e., blue, and red is made common. As shown in drawing 1 R> 1, the optical-axis joint prism 10 of this optical system is designed so that the divergence light beam of semiconductor laser LD1 and LD2 may be made with a common optical path, and has the function to carry out abbreviation coincidence of the optical axis of the laser beam of two wavelength. While the dichroic mirror 11 in the optical-axis joint prism 10 penetrates the 1st laser beam with a wavelength of 405nm, it is formed with the multilayer dielectric thin film so that it may have the property of reflecting the 2nd laser beam with a wavelength of 650nm and may have a dependency whenever [incident angle]. Moreover, without being limited to optical-axis joint prism, the optical-axis joint component which compounds an optical axis can be replaced with a dichroic mirror, and can use a diffraction grating, a liquid crystal cholesteric layer, etc. using the wavelength difference of an angle of diffraction for an optical-axis joint component.

[0014] Moreover, the optical pickup equips the lower stream of a river of the optical axis of the optical-axis joint prism 10 with the polarization beam splitter 13, the collimator lens 14, the quarter-wave length plate 15, and the objective lens unit 16. According to the above optical exposure optical system, the laser beam from either [at least] 1st semiconductor laser LD1 or 2nd semiconductor laser LD2 Through the optical-axis joint prism 10 and a polarization beam splitter 13, it is made a parallel light beam by the collimator lens 14, and the quarter-wave length plate 15 is penetrated. With the objective lens unit 16 It is condensed towards the optical disk 5 placed near [the] the focus, and an optical spot is formed on the pit train of the information recording surface of an optical disk 5.

[0015] In addition to the above optical exposure optical system, the optical pickup has photodetection optical system, such as the detection lens 17, further, and the objective lens unit 16, the quarter-wave length plate 15, and the polarization beam splitter 13 are used also for photodetection optical system. The reflected lights from the optical disk 5 of HD-DVD or DVD are collected in the objective lens unit 16, and are turned to the condenser lens 17 for detection by the polarization beam splitter 13 through the quarter-wave length plate 15. The focusing light condensed with the detection lens 17 forms an optical spot near the light-receiving side 20 core of the quadrisection photodetector which has four light-receiving sides which two segments which pass astigmatism generating components (not shown), such as a cylindrical lens and a multi-lens, for example, intersect perpendicularly come to quadrisect.

[0016] Moreover, the light-receiving side 20 of a photodetector is connected to the demodulator circuit 30 and the error detection circuit 31. The error detection circuit 31 is connected to the actuation circuit 33 which drives the device containing the actuator 26 the tracking control of an objective lens unit, and for focal control. A quadrisection photodetector supplies the electrical signal according to the optical spot image by which image formation was carried out near [the] the light-receiving side 20 core to a demodulator circuit 30 and the error detection circuit 31. A demodulator circuit 30 generates a record signal based on the electrical signal. The error detection circuit 31 generates a focal error signal, a tracking error signal, other servo signals, etc. based on the electrical signal, each driving signal is supplied to each actuator through the actuation circuit 33 of an actuator, and these carry out servo control actuation of the objective lens unit 16 etc. according to each driving signal.

(Objective lens unit) the objective lens unit of the optical pickup of this invention is shown in drawing 1 -- as -- blue laser light source LD1 of the short wavelength for HD-DVD, and the long wave for DVD -- the two light sources, merit's red laser light source LD2 and **, are used, the light beam from these is compounded to one optical path with the optical-axis joint prism 10, and it is made to condense on the optical disk recording surface of HD-DVD or DVD with the objective lens unit 16 This objective lens unit 16 is the assembly of the compound objective lens which combined diffracted-light study component 16b (DOE: diffractive opticalelement) which has diffraction gratings, such as a Fresnel lens which consists of two or more irregularity, or a hologram lens, on condenser lens (criteria lens) 16a which condenses a light beam to a recording surface, and the plate of translucency, as shown in drawing 1 . Condenser lens 16a and diffracted-light study component 16b are arranged by holder 16c on the same axle at an optical axis, and diffracted-light study component 16b which has a diffraction grating is located in the optical path from the light source side 10, i.e., optical-axis joint prism, to condenser lens 16a.

[0017] The aspheric lens with which it is the blue wavelength range of 400nm - 410nm or the red wavelength range of 630nm - 660nm, or aberration was amended in the blue wavelength range at least is used for condenser lens 16a. Generally, since it normalizes on wavelength and tolerance becomes severe in inverse proportion to wavelength, if it compares on the wavelength of red and blue, since the direction from which the desirable property in blue wavelength is taken out will become difficult, as for aberration, it is desirable to use the aspheric lens with which aberration was especially amended in the blue wavelength range.

[0018] As diffracted-light study component 16b consists of glass, plastics, etc. and the diffraction-grating 16e is shown in drawing 2 , it consists of zona orbicularis of the circular sulcus by which was cut by two or more concentric circles centering on the optical axis, or the laminating was carried out with phot lithography, or a convex. As are shown in drawing 3 , and the cross section shows a blaze configuration, i.e., serrate, or drawing 4 , diffraction-grating 16e is formed so that it may become a stairway configuration. For example, since diffraction efficiency is higher than others, the diffraction grating of a serrate cross section is advantageous. Which approach may be used, although there are an approach of applying a photolithography technique, and the approach of carrying out a precision cut with a diamond tool etc. as a method of creating a diffraction-grating cross-section configuration and the diffraction grating of the multistage story blaze which formed the blaze in false by these, or a blaze configuration is made. Or the form is formed in metal mold for this multistage story blaze or the blaze configuration, and two or more diffracted-light study components can also be reproduced from a transparent material by injection molding or 2P so-called law.

[0019] Diffracted-light study component 16b consists of 16d of plano-concave lenses, and diffraction-grating 16e formed in the concave surface of a plano-concave lens, as shown in drawing 3 and drawing 4 . It is because the effect to which the wavelength dependence property described later improves with a concave lens, and is deteriorating with a convex lens reversely arises to the property of condenser lens 16a which fixed the best image point to use the substrate of diffracted-light study component 16b as a concave lens. Moreover, as a diffracted-light study component, it can replace with 16d of plano-concave lenses, 16d of light transmission nature plates can be used as a substrate, and diffraction-grating 16e can also use the component formed in the front face.

[0020] When the 1st blue light beam with a wavelength of 405nm penetrates as shown in drawing 5 (A) for example, diffraction-grating 16e of diffracted-light study component 16b is formed so that the secondary diffracted-light B-2 may be condensed on a HD-DVD disk recording surface through condenser lens 16a as information reading light or an information record light. Moreover, simultaneously, as shown in drawing 5 (B), when the 2nd light beam of red with a wavelength of 650nm penetrates, diffraction-grating 16e is formed so that the primary diffracted light R1 of a low degree may be condensed on a DVD disk recording surface through an objective lens as information reading light or an information record light from the secondary diffracted light of the 1st light beam diffracted light. Since zero-order [blue] and the primary diffracted lights B0 and B1 will be in a focus condition in the red zero-order diffracted light R0 and a red high order diffracted-light list on a disk recording surface in these cases, these diffracted lights hardly influence reading or record. Although the 1st and 2nd light beams of the light source, i.e., the wavelength range of the semiconductor laser of red and blue, are made into red (630-660nm) and blue (400-410nm) in the above-mentioned example, respectively, it is because diffraction efficiency will not change a lot if it is this range. Furthermore, as for the 1st order of diffraction of the 1st light beam diffracted light, only 1 is larger than the 2nd order of diffraction of the 2nd light beam diffracted light, and, as for the 2nd order of diffraction of the 2nd light beam diffracted light, it is desirable that it is one or more. Therefore, when the 3rd diffracted light with a wavelength of 405nm other than the above-mentioned example whose 2nd light beam diffracted light is the primary diffracted light when the 1st light beam diffracted light is the secondary diffracted light is used for HD-DVD at the 1st light beam diffracted light, diffraction-grating 16e of diffracted-light study component 16b may be produced so that the secondary diffracted light may be condensed as the 2nd light beam diffracted light with a wavelength of 650nm for DVD.

[0021] Generally, by the compatible optical pickup, in order to obtain optical reinforcement in one

reading light, the diffracted lights other than the zero-order diffracted light are used for the reading light of another side using the diffraction grating without zero-order diffracted light, i.e., power, but without using the zero-order blue diffracted light with red, using the secondary blue diffracted light, in red, the diffraction grating is formed so that the primary diffracted light of a low degree [one] may be used from the 2nd order. That is, the diffraction grating of this invention is formed so that the respectively high rate of the diffracted light may be obtained in the optical-path-length difference to the order of diffraction which needs blue wavelength with red.
[0022] For example, change of the diffraction efficiency of a diffraction grating at the time of producing the diffracted-light study component which consists of plastic material of OZ-1000 (Hitachi Chemical) as a base material is computed by changing depth d of a diffraction grating to 0-3 micrometers, using a pitch P as 160-260 micrometers for the diffraction grating of the blaze cross-section configuration shown in drawing 3 . Since the pitch is longer than wavelength enough, the diffraction grating in the gestalt of operation can apply the scalar theory, and since the depth is wavelength extent, it can treat it as the so-called thin film grating. In that case, diffraction-efficiency etam is expressed with the-one number of degree types (m is the order of diffraction).
[0023]
[Equation 1]

$$\eta m = \left| \frac{1}{T} \int_0^T A(x) \exp\{i\varphi(x)\} \exp(-i\frac{2\pi mx}{T}) dx \right|^2$$

[0024] Among the formula, in A (x), transparency amplitude distribution and psi (x) show phase distribution, and T shows the pitch of a grating. In count, it has standardized as A(x) =1. Moreover, the wavelength dependency of aberration improves so that a pitch generally becomes fine about the pitch of a diffraction grating, but if a pitch becomes 5 or less times of wavelength, diffraction efficiency will fall greatly theoretically. Moreover, the effect by configuration gap becomes large, so that a pitch is fine. So, with the gestalt of this operation, a configuration gap of pitch 1micrometer makes 20 micrometers or more a desirable value as a value which corresponds to 5%.
[0025] Drawing 6 is the result of computing depth [of a diffraction grating] d on an axis of abscissa, and computing change of the diffraction efficiency of a diffraction grating on an axis of ordinate. "B0" in drawing, "B1", "B-2", and "B3" show the diffraction efficiency of the blue zero-order diffracted light, the primary diffracted light, the secondary diffracted light, and the 3rd diffracted light, and "R0", "R1", and "R2" show the diffraction efficiency of the red zero-order diffracted light, the primary diffracted light, and the secondary diffracted light, respectively.
[0026] As for the blaze-ized diffraction grating, diffraction efficiency takes [the phase depth] maximum with the period of every one wave lambda of light so that clearly from drawing 6 . The phase depth of a diffraction grating is expressed with these products d (n-1), when d is made into the depth of a actual diffraction grating and it makes n the refractive index of a diffracted-light study component base material. Since it is rate nR=of isometropia 1.498, if it calculates to the wavelength of lambda= 650nm by refractive-index nB=1.531 of a base material ingredient after this to the wavelength of lambda= 405nm, the depth of the diffraction grating from which phase contrast is set to one wave lambda by 405nm will be 0.763 micrometers, and the diffraction efficiency of the blue primary diffracted light will become max in this depth. the blue secondary diffracted light -- the twice -- 1.526 micrometers of red primary diffracted lights serve as max by 1.305 micrometers similarly.
[0027] It turns out that the depth of the diffraction grating from which the high rate of the diffracted light is obtained from these things on any blue wavelength with red is the intersection of R1 and B-2, and the intersection of R2 and B3. That is, near 1.42 micrometer used by secondary diffracted-light B-2 of the blue of the 1st wave and the primary diffracted light R1 of the red of the 2nd wave and near 2.4 micrometer which are used by the 3rd blue diffracted light B3 and the red secondary diffracted light R2 are the depth of the diffraction grating from which the rate of the high diffracted light is obtained. Since it will become about about ten% of effectiveness reduction if 0.2 micrometers of depth of a diffraction grating shift, in order to secure more than this, it is desirable that the depth of the diffraction grating

from which the rate of the high diffracted light is obtained considers as within the limits of 1.42**0.2 micrometers or 2.40**0.2 micrometers.
[0028] Moreover, although the rate of the diffracted light is by no means as low as about 80% also on the intersection (the depth of a diffraction grating is 0.965 micrometers) of the primary diffracted light B1 of the blue of the 1st light, and the primary diffracted light R1 of the red of the 2nd wave, if a gap arises in the depth of a diffraction grating, diffraction efficiency will fall greatly, so that clearly from drawing 6 . Although there is little fluctuation of diffraction efficiency if it is an intersection blue and near the peak of red diffraction efficiency even if a gap arises in the depth of a diffraction grating since the peaks of the diffraction efficiency of the blue secondary diffracted light [3rd] are a depth of 1.526 micrometers, and 2.289 micrometers and it is 1.305 micrometers and 2.610 micrometers in red primary secondary diffracted light similarly, on the intersection which separates from each peak, it changes sharply.
[0029]
[Example 1] As an optical pickup which has such a function, the diffraction grating as shown in drawing 5 produced the optical pickup containing the objective lens unit which used the diffracted-light study component using the primary diffracted light as another object with the condenser lens to the secondary diffracted light and red (650nm) to blue (405nm), and was designed as a symmetry-of-revolution object centering on an optical axis. The zona-orbicularis pattern of a diffraction grating, i.e., the zona-orbicularis number of a diffraction grating, is five in measuring area. The data of a radius and a pitch are as in a table 1.
[0030]
[A table 1]

輪帯番号	半径 (mm)	ピッチ (mm)
1	1.005975	
2	1.264028	0.258053
3	1.444862	0.180834
4	1.610726	0.165864
5	1.831136	0.220410

[0031] As shown in drawing 5 , the diffracted-light study component of the lens of **** has been arranged at the light source side of the condenser lens of the aspheric surface, the diffraction grating was formed on the concave surface, and each of concave surfaces and diffraction gratings was made into the aspheric surface configuration. Therefore, the 1st page and the 2nd page are the plane of incidence and the outgoing radiation sides of a diffracted-light study component, and the 3rd page and the 4th page are the plane of incidence and the outgoing radiation sides of a condenser lens. Each aspheric surface Z is expressed with the-two number of degree types.
[0032]
[Equation 2]

$$Z = \frac{(1/R)r^2}{1+\sqrt{1-(1/R)^2(K+1)r^2}} + \sum_i ASir^i$$

[0033] (However, the amount of Z:SAG, R:radius of curvature, K:constant of the cone, the radius from r:optical axis, ASi: Aspheric surface multiplier)
Phase function phi (r) is expressed with the-three number of **** types.
[0034]
[Equation 3]

[0035] (However, the dor:order of diffraction, lambda0:wavelength, the radius from r:optical axis, DF1-DF5: Multiplier)
The data of each aspheric lens by which design automation was carried out are as in tables 2-4.
[0036]
[A table 2]

	面番号	曲率半径	面間隔	屈折率
回折光学素子	1	280.370891V	1.000000	1.518981
	2	—	0.300000	
基準レンズ	3	2.164335	1.900000	1.605257
	4	-16.344600	1.000000	
ディスク	5	—	0.600000	1.621082
	6	—	0.875242 V	

[0037]
[A table 3]

		第1面	第3面	第4面
非球面係数	AS2	-0.001558	0.002689	0.008334
	AS3	0.000155	0.000265	-0.001575
	AS4	3.9939e-05	5.0945e-06	0.000217
	AS5	-2.7633e-06	2.8945e-06	-1.5435e-05
円 錐 係 数 (K)		-8.1804e+04	-0.685540	-34.016419

[0038]
[A table 4]

	第1面
DF0	-0.000200
DF1	0.000225
DF2	-0.000491
DF3	5.5800e-05
DF4	8.1529e-06
DF5	-5.0055e-07

[0039] Change of the wave aberration to HD-DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 405**5nm) of the objective lens unit obtained by drawing 7 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0040] Drawing 8 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 405nm. The wave aberration of an objective lens unit is stopped to about 0.8 field angles below at MARESHARU marginal 0.07lambda so that it may illustrate. Change of the wave aberration to DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 650**10nm) of the objective lens unit obtained by drawing 9 R> 9 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped very low below at

MARESHARU marginal 0.07lambda so that it may illustrate.
[0041] Drawing 10 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 650nm. The wave aberration of an objective lens unit is less than one field angle, and is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate. In addition, drawing 11 was what graph-ized change of the amount of wave aberration about the primary diffracted light [secondary] of each wavelength of drawing 7 and drawing 9 , took the wavelength to 400nm - 700nm along the axis of abscissa, and took wave aberration along the axis of ordinate. In addition, drawing 7 to drawing 11 calculated the amount of wave aberration of a there by having asked for the best image point location to each wavelength, and evaluated wave aberration (the so-called best image point location adjustable).
[0042] Furthermore, for the comparison, the wavelength dependency property of the objective lens simple substance only for blue was measured, and it compared with the thing of the above-mentioned example. The result is shown in drawing 12 . A shows the wavelength of the secondary diffracted light of the blue of this example, and the relation of aberration among a graph, and B shows the wavelength in the single objective lens for blue of the example of a comparison, and the relation of aberration. It turns out that the wavelength range where the way in the case of this example is more nearly usable than the case where the exclusive lens of a simple substance is used is wide. This is because the concave lens (plano-concave lens) is used as a diffracted-light study component, and, thereby, the wavelength dependence property is improved from the objective lens only for blue of a simple substance. In addition, drawing 12 asked for the best image point location in one wavelength, it calculated the amount of wave aberration in other wavelength by having fixed to the location, and evaluated wave aberration (the so-called best image point location immobilization). With wavelength, since the best image point location which becomes the min of wave aberration changes, it has been the conditions that the best image point location immobilization of drawing 12 is surely severer from the best image point location adjustable case of drawing 7 and drawing 11 R> 1.
[0043]
[Example 2] Furthermore, the diffraction grating shown in drawing 13 (A) and (B) produced the optical pickup containing the objective lens unit which used diffracted-light study component 16b using the secondary diffracted light R2 as another object with condenser lens 16a to the 3rd diffracted light B3 and red (650nm) to blue (405nm), and was designed as a symmetry-of-revolution object centering on an optical axis as an optical pickup of an example 2. The zona-orbicularis pattern of a diffraction grating is the same as that of an example 1.
[0044] The data of each aspheric lens manufactured by carrying out design automation are as in tables 5-7.
[0045]
[A table 5]

	面番号	曲率半径	面間隔	屈折率
回折光学素子	1	-596.869760 V	1.000000	1.518981
	2	—	0.300000	
基準レンズ	3	2.161390	1.798000	1.605257
	4	-17.079390	1.000000	
ディスク	5	—	0.600000	1.621082
	6	—	0.876211 V	

[0046]
[A table 6]

		第1面	第2面	第3面
非球面係数	AS2	-0.001291	-0.000738	0.008569
	AS3	0.000262	-0.000211	-0.003385
	AS4	-9.5306e-05	-0.000123	0.000760
	AS5	4.8087e-06	2.9546e-06	-6.4927e-05
円錐係数 (K)		-1.2380e+05	-0.418560	17.362981

[0047]
[A table 7]

	第1面
DF0	-0.000200
DF1	0.000289
DF2	-0.000203
DF3	3.7316e-05
DF4	-1.5262e-05
DF6	7.8578e-07

[0048] Change of the wave aberration by the 3rd diffracted light to HD-DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 405**5nm) of the objective lens unit obtained by drawing 14 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0049] Drawing 15 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 405nm. The wave aberration of an objective lens unit is stopped to about 0.8 field angles below at MARESHARU marginal 0.07lambda so that it may illustrate. Change of the wave aberration by the secondary diffracted light to DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 650**10nm) of the obtained objective lens unit is shown in drawing 1616 . The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0050] Drawing 17 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 650nm. The wave aberration of an objective lens unit is less than one field angle, and is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0051]
[Example 3] Furthermore, the diffraction grating shown in drawing 18 (A) and (B) produced the optical pickup containing the objective lens unit 16 which made one the diffracted-light study component and condenser lens using the primary diffracted light R1 to secondary diffracted-light B-2 and red (650nm) to blue (405nm), and was designed as a symmetry-of-revolution object centering on an optical axis as an optical pickup of an example 3. The zona-orbicularis pattern of a diffraction grating is the same as that of an example 1.
[0052] As shown in drawing 18 , the diffraction grating was formed on the plane of incidence by the side of the light source of the condenser lens of the aspheric surface, and each of diffraction gratings and outgoing radiation sides of a condenser lens was made into the aspheric surface configuration. Therefore, the 1st page and the 2nd page are really the diffraction gratings and outgoing radiation sides of a condenser lens. The data of each aspheric lens manufactured by carrying out design automation are

as in tables 8-10.
[0053]
[A table 8]

	面番号	曲率半径	面間隔	屈折率
複合対物レンズ	1	2.512042 V	1.798000	1.605257
	2	138.437197 V	1.000000	
ディスク	3	—	0.600000	1.621082
	4	—	0.801256 V	

[0054]
[A table 9]

		第1面	第2面
非球面係数	AS2	-8.7995e-05	-0.007221
	AS3	0.000417	-0.001463
	AS4	2.3084e-05	-0.000487
	AS5	1.8366e-06	5.7676e-05
円錐係数 (K)		-0.441017	-2.4545e+04

[0055]
[A table 10]

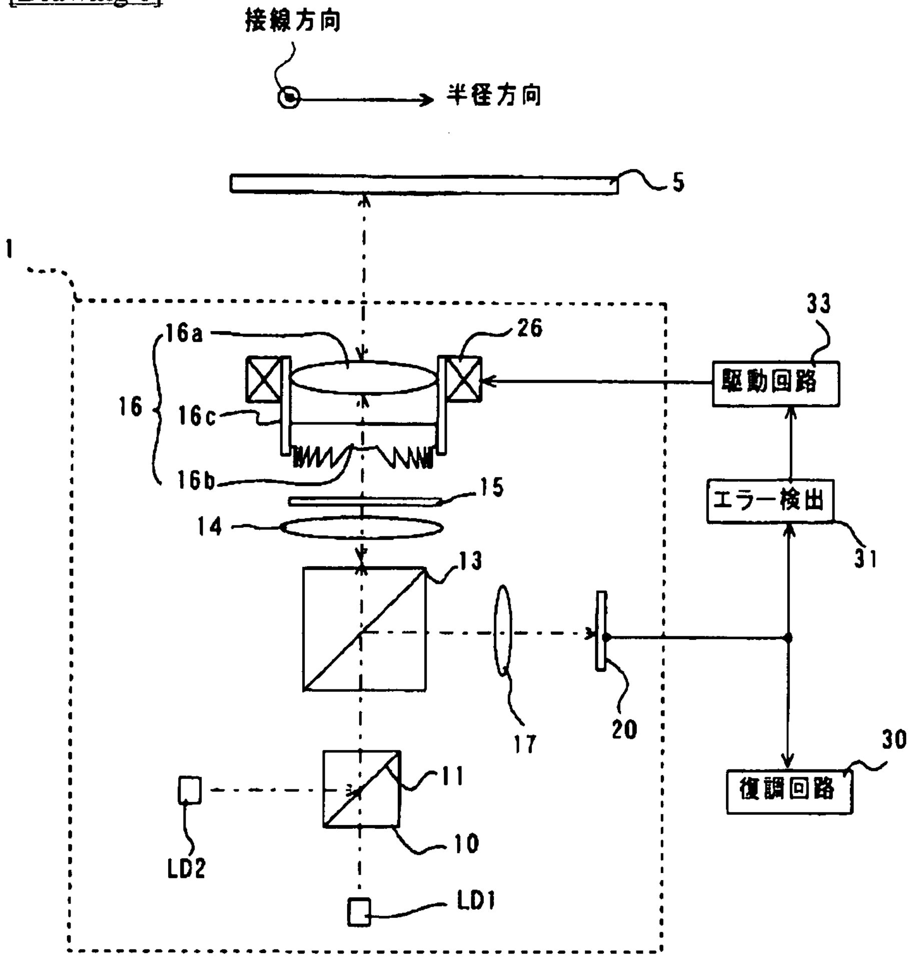
	第1面
DF1	-0.016154
DF2	-0.000703
DF3	7.6145e-05
DF4	-1.1684e-05
DF5	-3.8137e-06

[0056] Change of the wave aberration to HD-DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 405**5nm) of the objective lens unit obtained by drawing 19 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0057] Drawing 20 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 405nm. The wave aberration of an objective lens unit is stopped to about 0.95 field angles below at MARESHARU marginal 0.07lambda so that it may illustrate. Change of the wave aberration to DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 650**10nm) of the objective lens unit obtained by drawing 21 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing is shown. The wave aberration of an objective lens unit is stopped very low below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0058] Drawing 22 is the graph with which the field angle was taken along the axis of abscissa, and it took wave aberration along the axis of ordinate on the single wavelength of 650nm. The wave aberration of an objective lens unit is stopped to about 0.95 field angles below at MARESHARU marginal 0.07lambda so that it may illustrate.

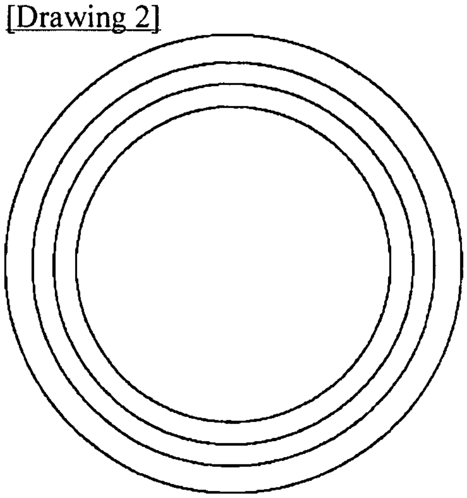
[0059]
[Effect of the Invention] According to this invention, the objective lens in an optical pickup as a compound objective lens which consists of a condenser lens and a diffracted-light study component a diffracted-light study component When the 1st light beam penetrates a diffracted-light study component, the 1st light beam diffracted light of the 1st order of diffraction is condensed through a condenser lens as information reading light or an information record light and the 2nd light beam penetrates a diffracted-light study component, Since it has the transmission grating which consists of two or more irregularity which condenses the 2nd light beam diffracted light of the 2nd order of diffraction of a low degree through a condenser lens as information reading light or an information record light from the 1st order of diffraction of the 1st light beam diffracted light The miniaturization optical pickup in which an account rec/play student is possible can be obtained to the optical disk or recording surface from which response wavelength differs. thus, the thing for which the diffraction grating of direct or another object is formed in an objective lens -- following ability -- there is effectiveness [like]. An objective lens and a diffracted-light study component lens can be supported with the same electrode holder, it can miniaturize, and a problem does not occur to migration of a lens. The configuration of another object is also an operation of extent which amends high order aberration to both the wavelength of red and blue that location precision is loose, that is, is used since a diffracted-light study component hardly carries out a refraction operation, and the far loose manufacture of the mutual physical relationship with an objective lens is attained compared with other approaches. When using the lens especially amended in blue or the red wavelength range as an objective lens, the design eased far is attained.

[Translation done.]

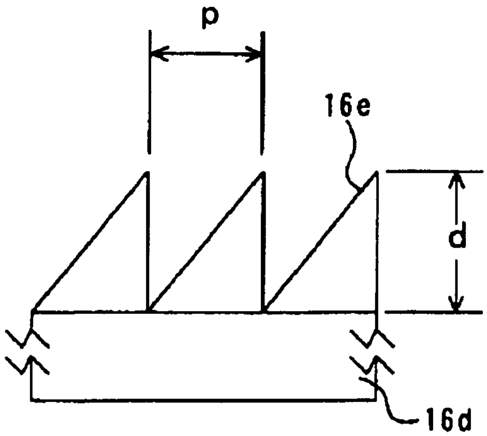
[Drawing 1]



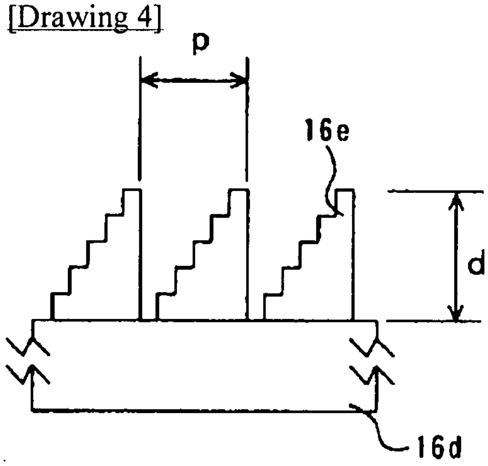
[Drawing 2]



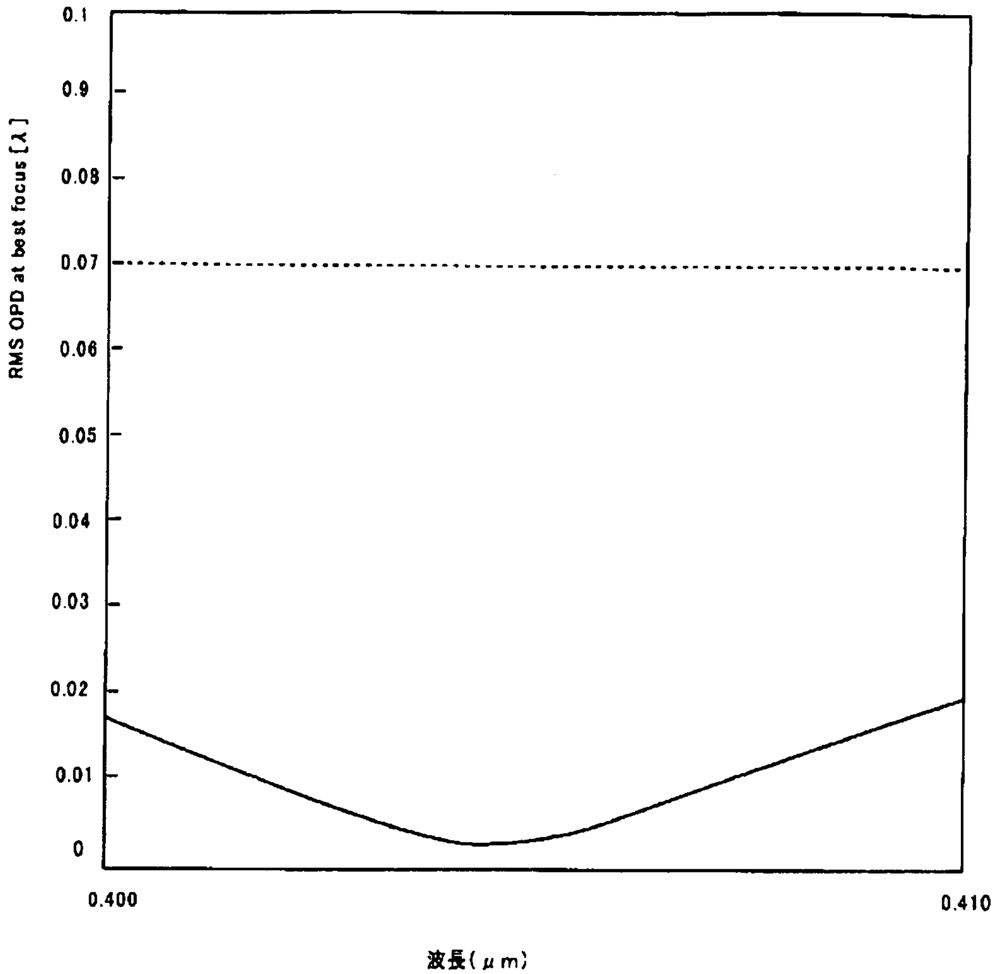
[Drawing 3]



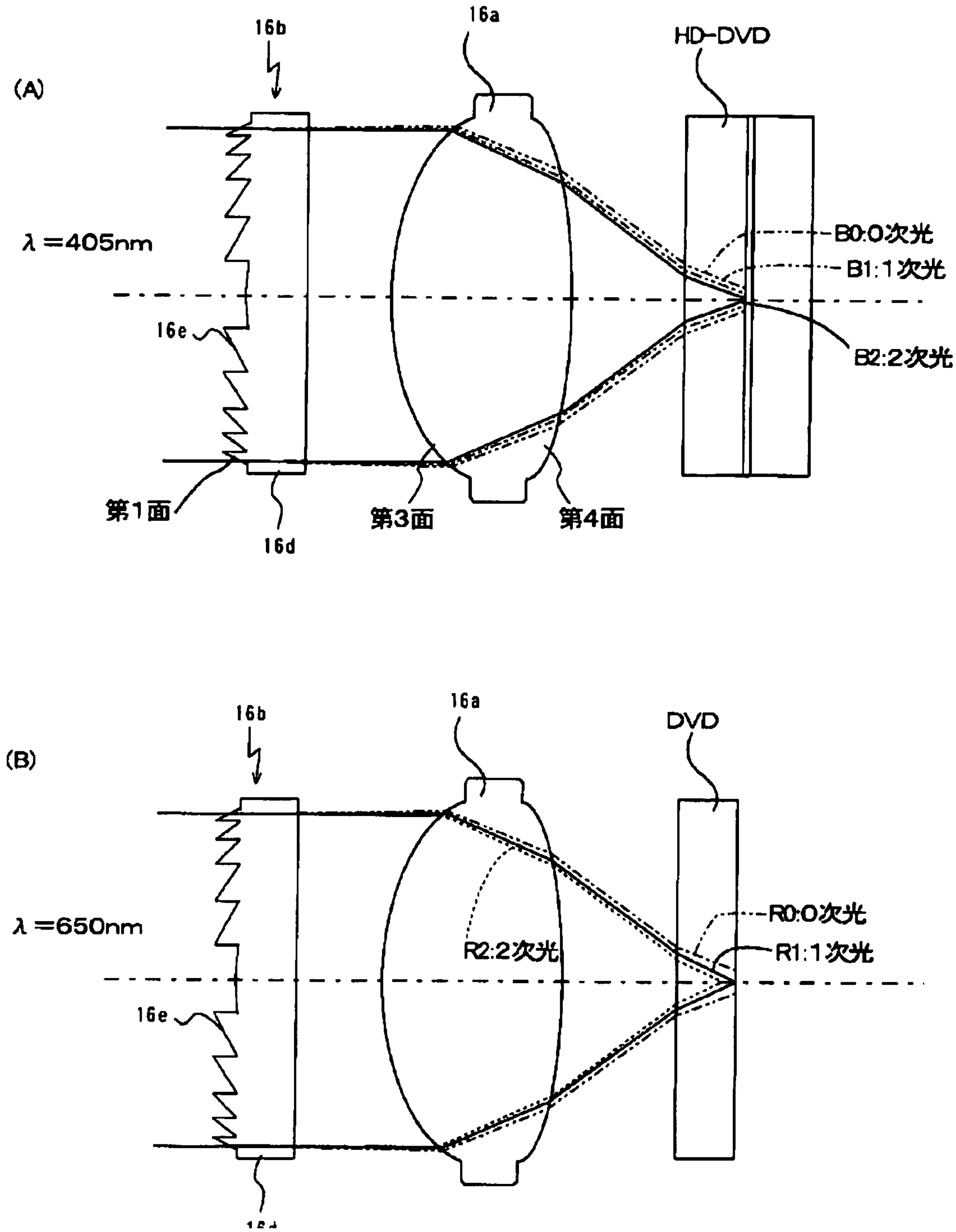
[Drawing 4]



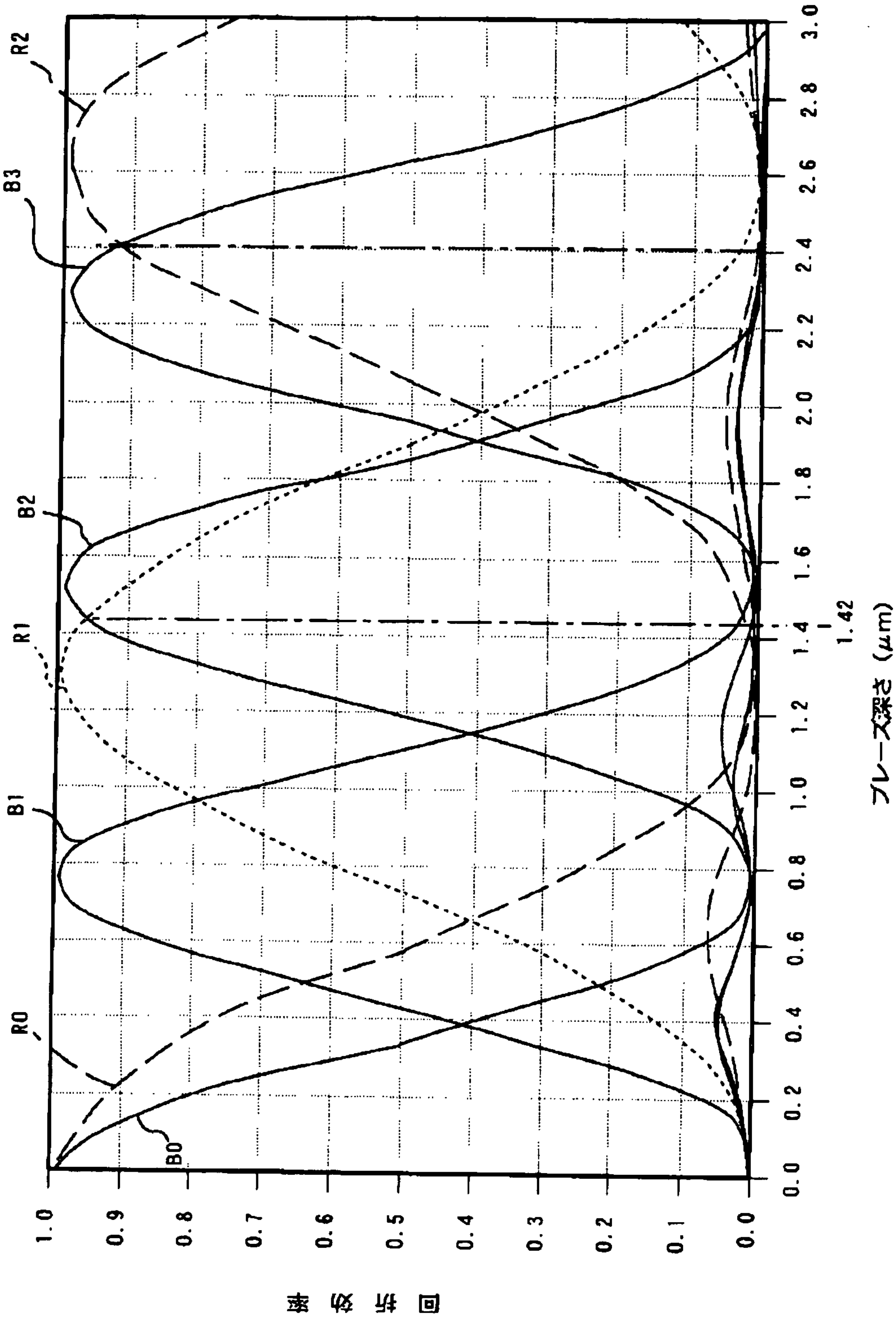
[Drawing 7]


RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.400
0.410
波長（μm）

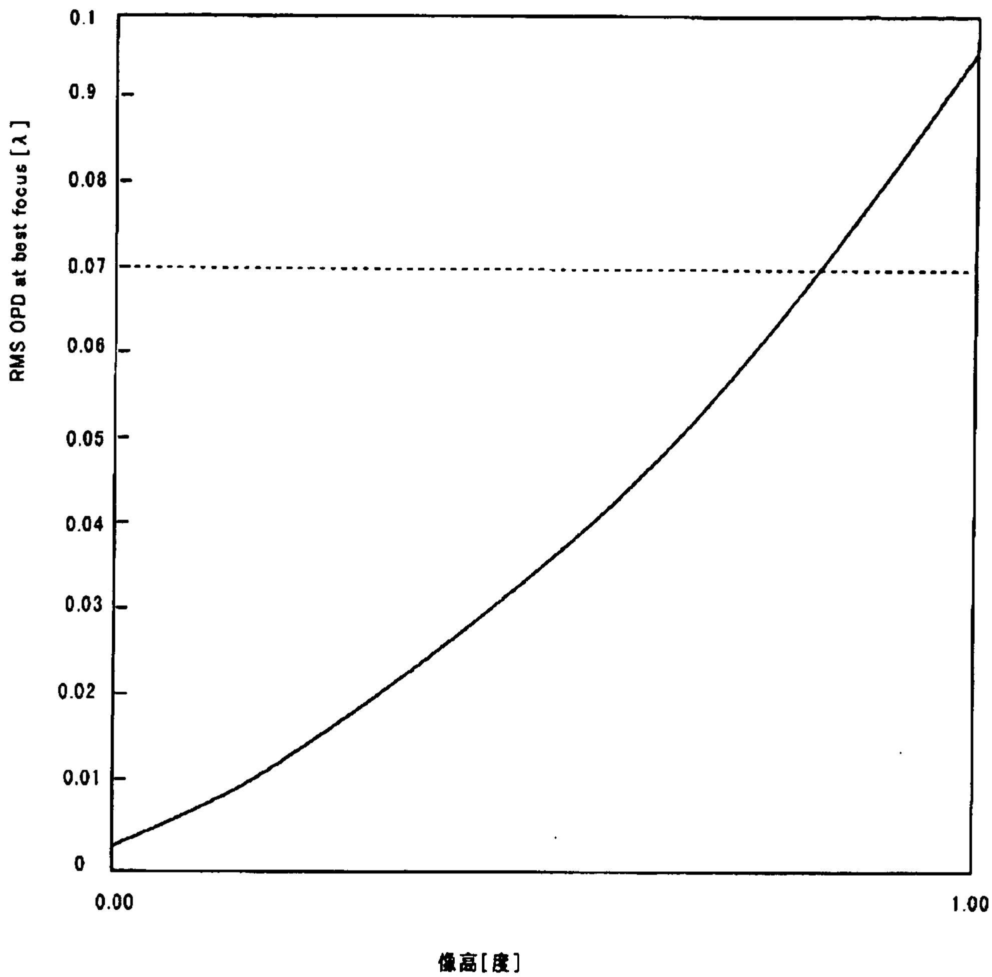
[Drawing 5]


(A)
16b
16a
HD-DVD
λ=405nm
B0:0次光
B1:1次光
16e
B2:2次光
第1面
16d
第3面
第4面
(B)
16b
16a
DVD
λ=650nm
R0:0次光
R2:2次光
R1:1次光
16e

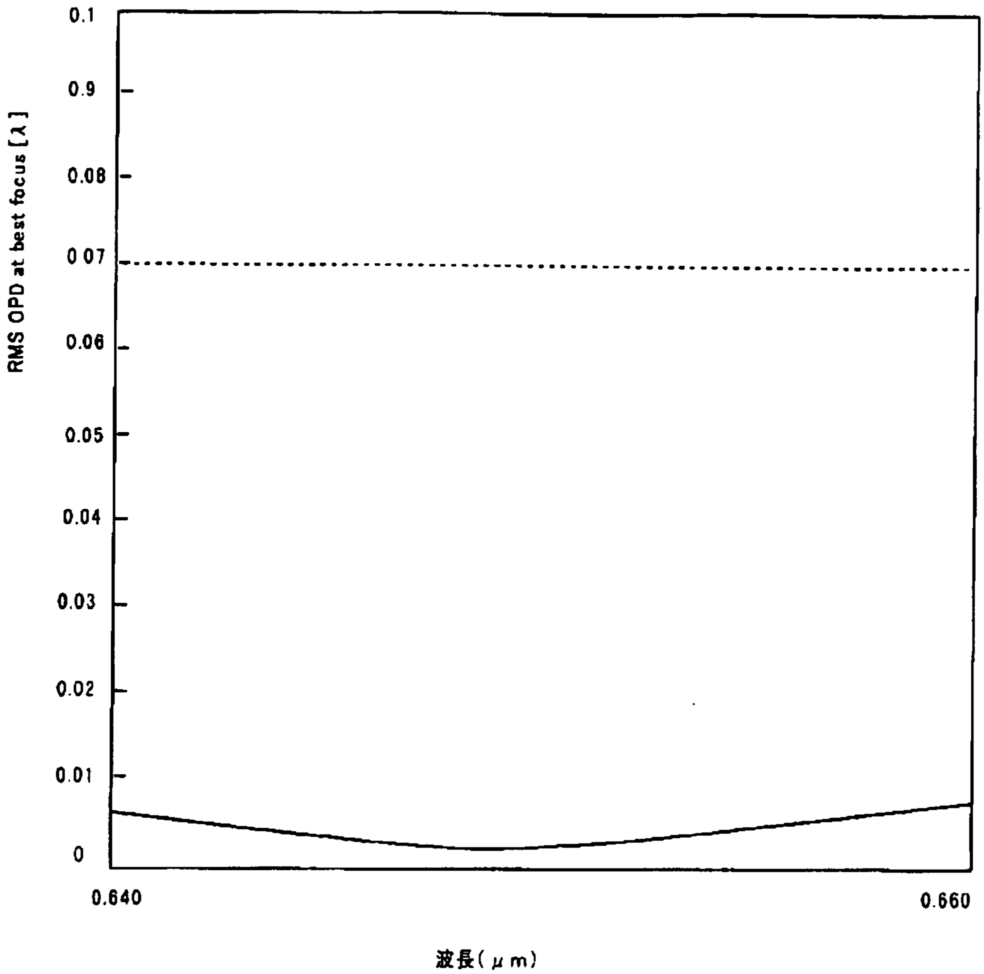
[Drawing 6]


R2
B3
B2
R1
B1
R0
B0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.42
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
ブレーズ深さ (μm)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
回折効率

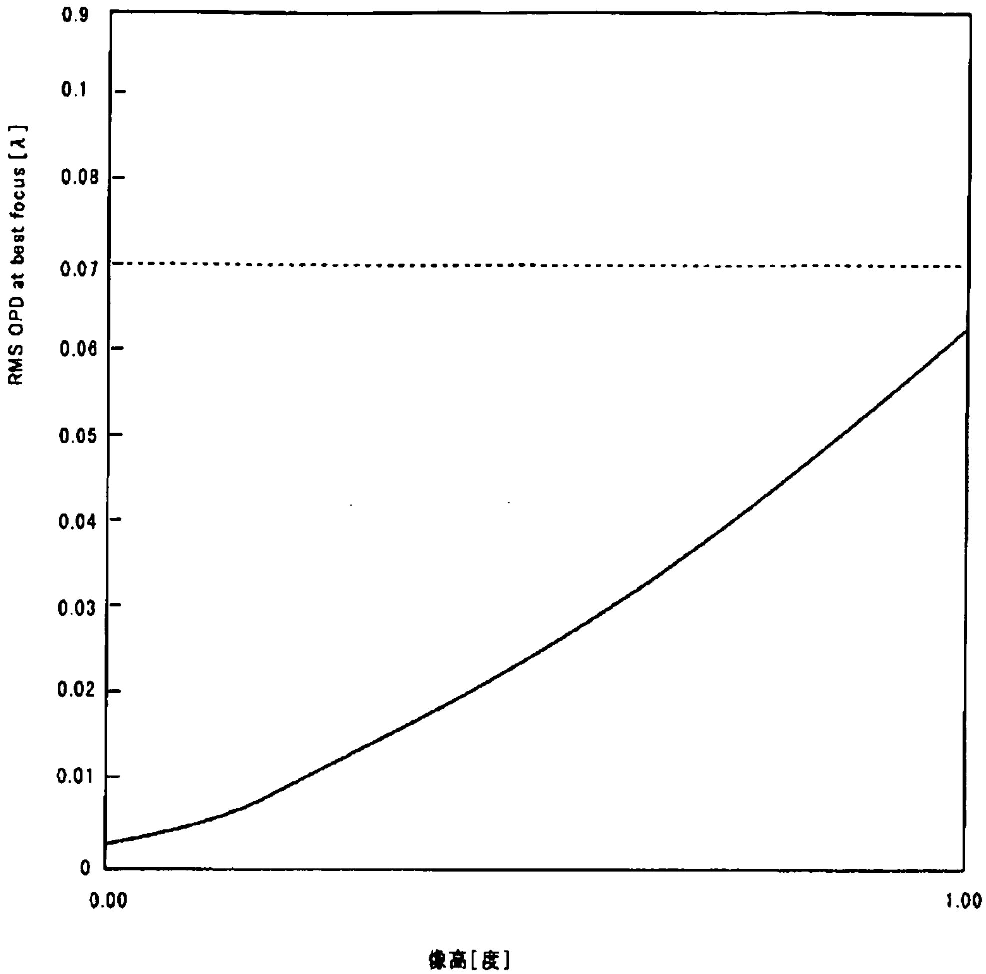
[Drawing 8]


0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.00
1.00
像高[度]

[Drawing 9]

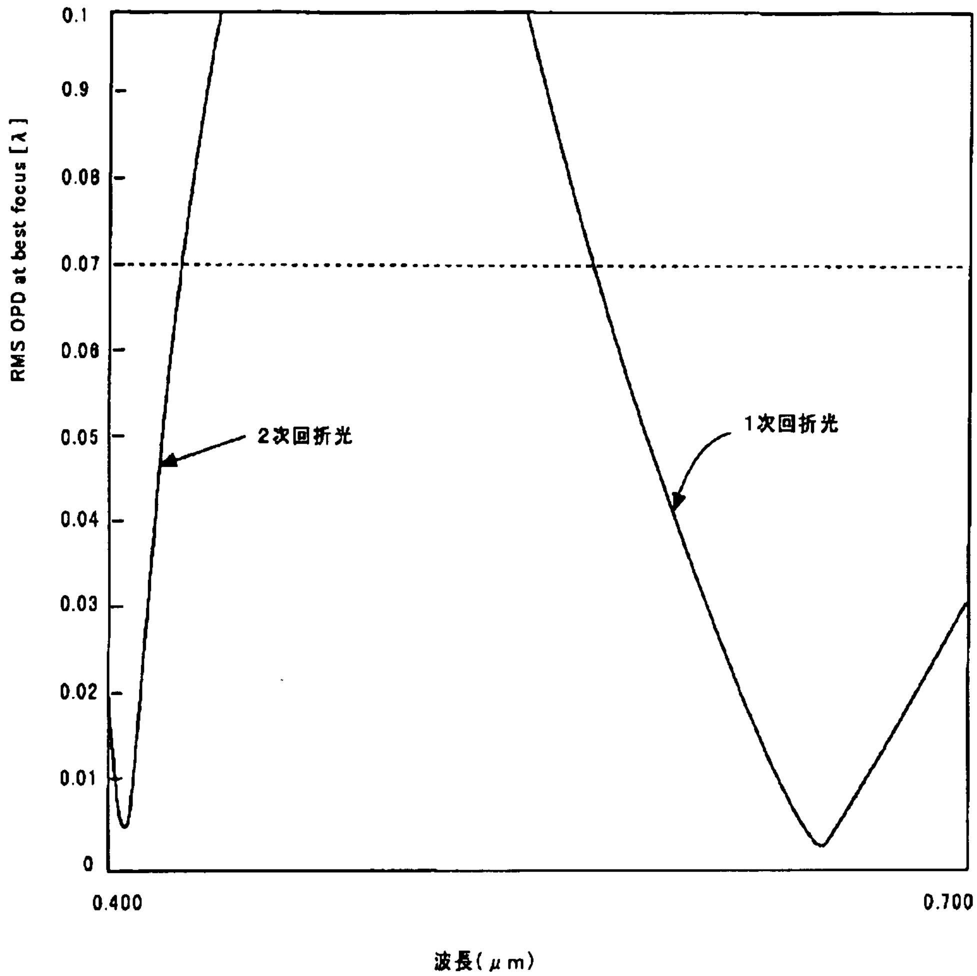

RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.640
0.660
波長(μm)

[Drawing 10]

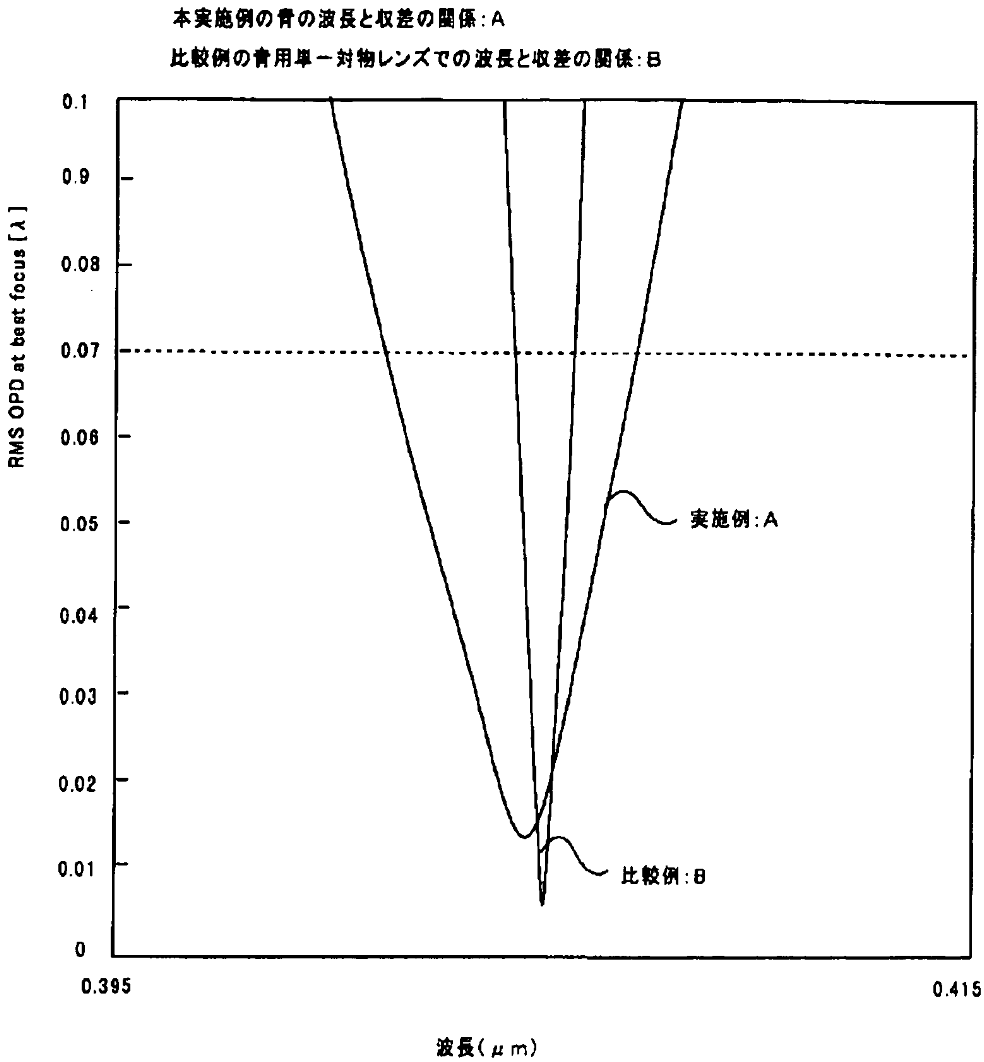


RMS OPD at best focus [λ]
0.9
0.1
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.00
1.00
像高[度]

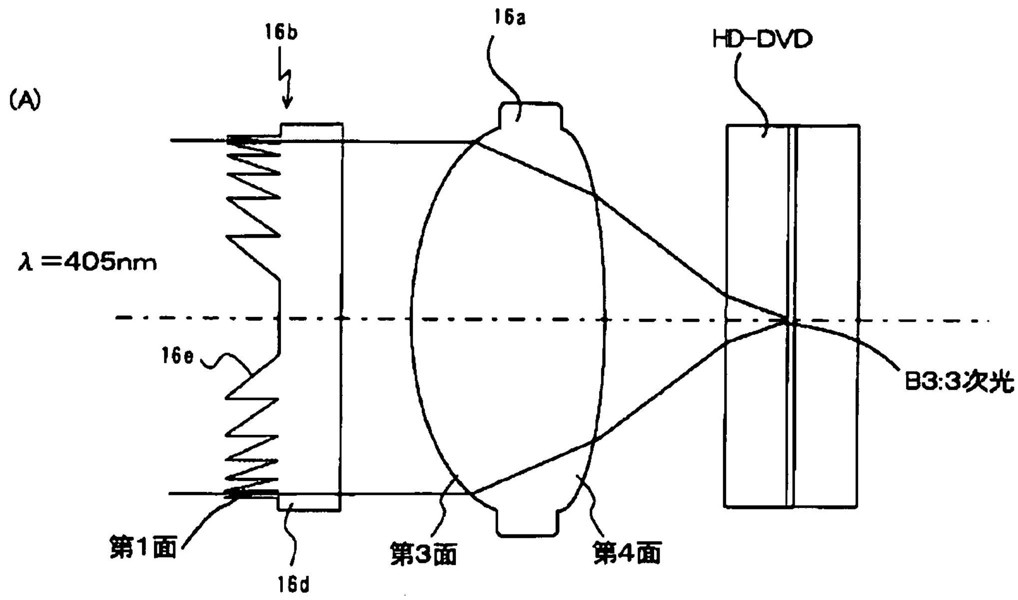
[Drawing 11]

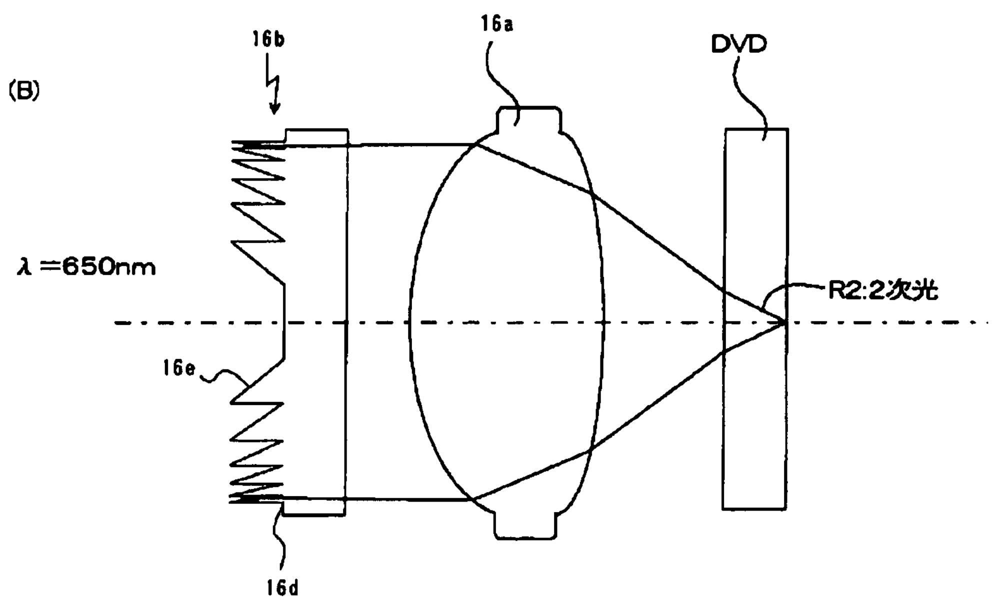

RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2次回折光
1次回折光
0.400
0.700
波長(μm)

[Drawing 12]

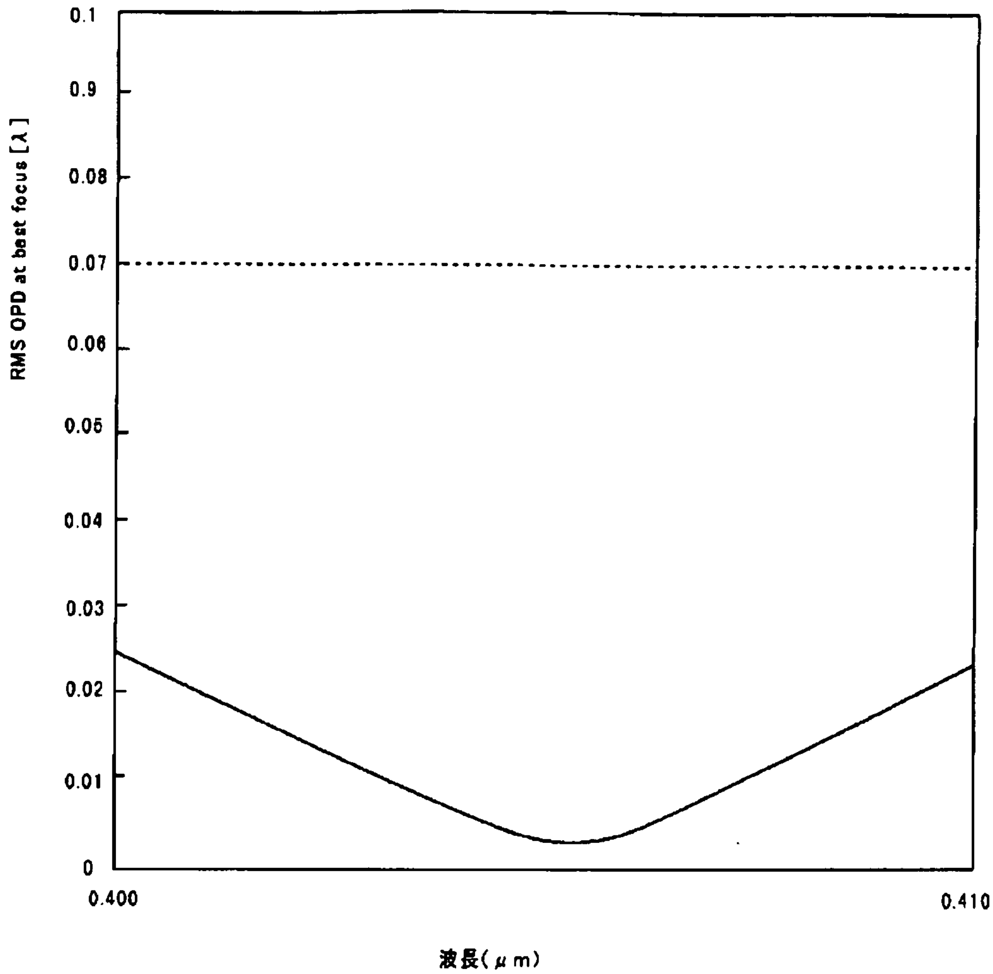

本実施例の青の波長と収差の関係：A
比較例の青用単一対物レンズでの波長と収差の関係：B
RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.395
0.415
実施例：A
比較例：B
波長（μm）

[Drawing 13]

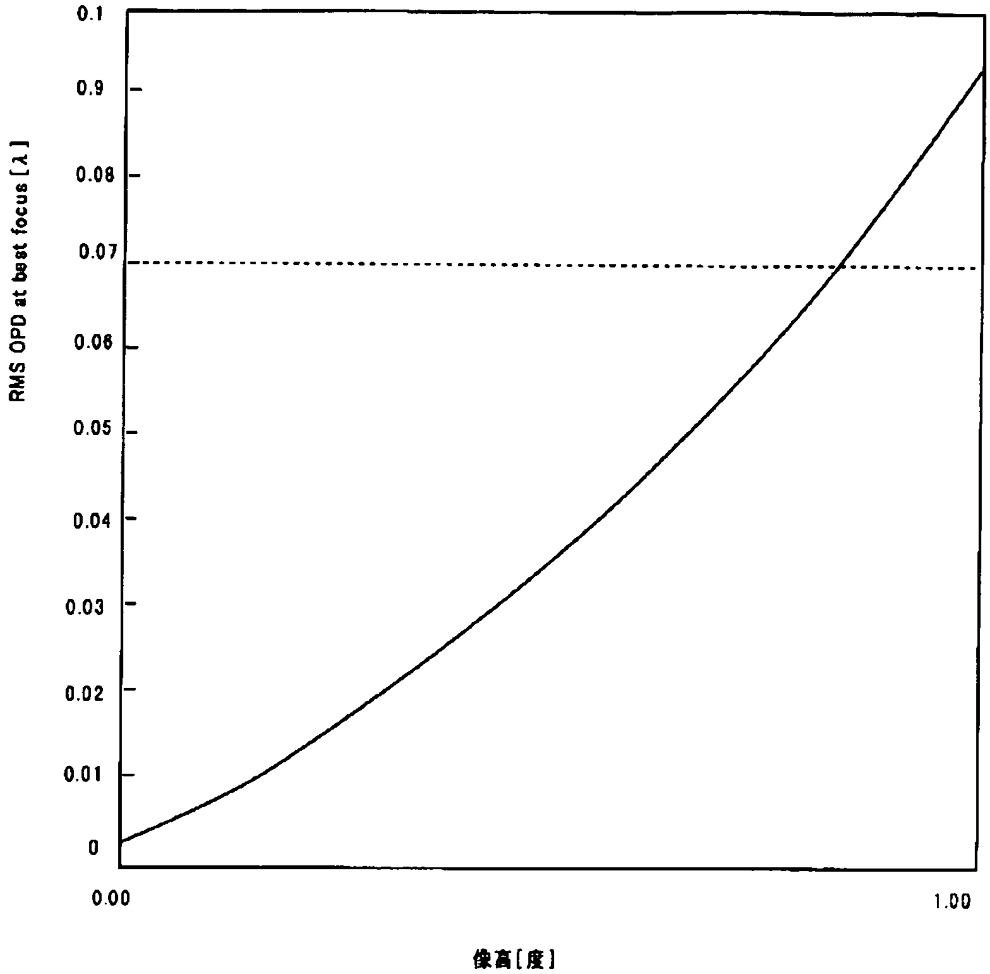

(A)
16b
16a
HD-DVD
λ=405nm
16e
B3:3次光
第1面
16d
第3面
第4面


(B)
16b
16a
DVD
λ=650nm
R2:2次光
16e
16d

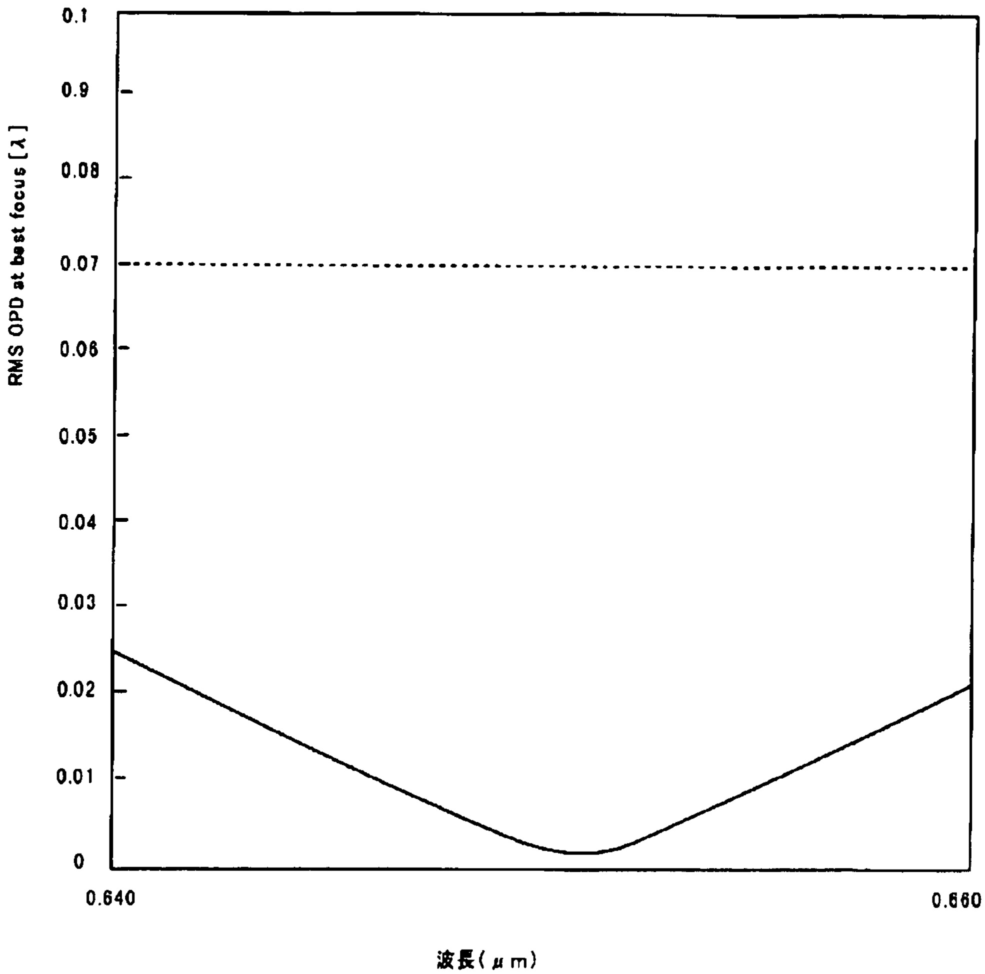
[Drawing 14]


RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.400
0.410
波長(μm)

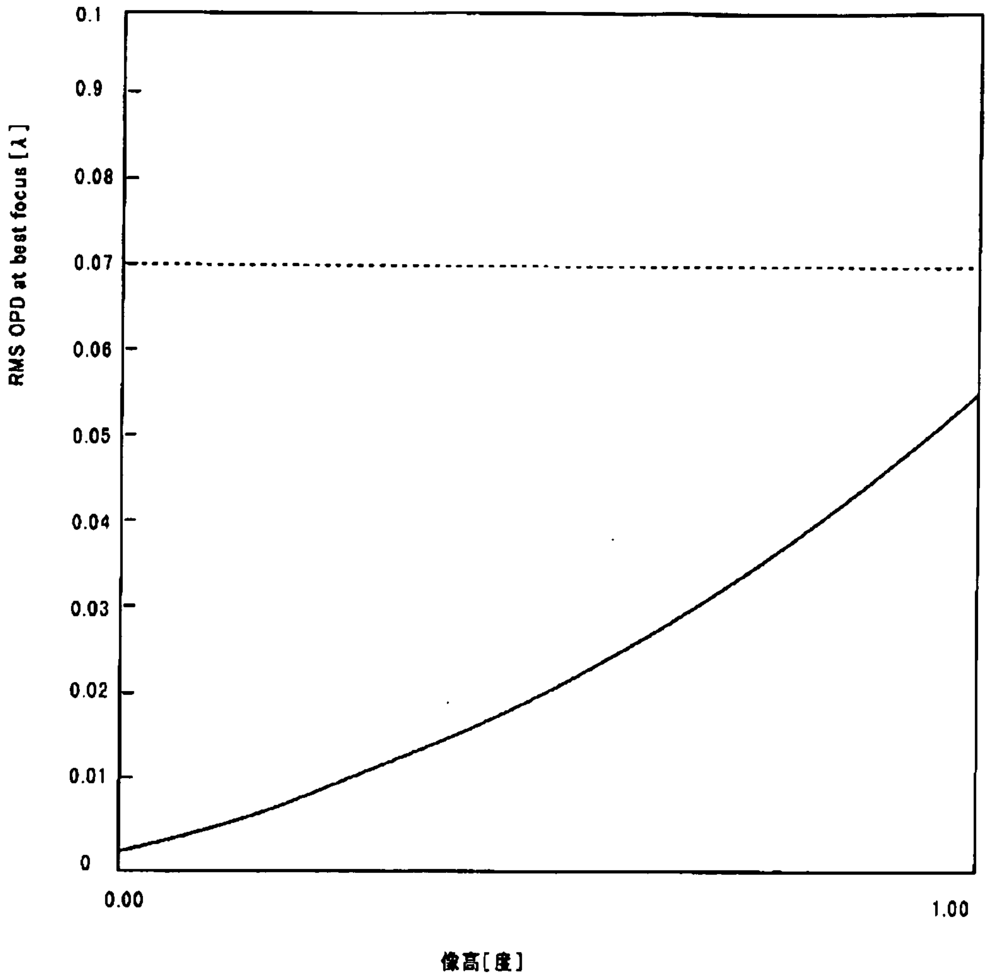
[Drawing 15]


0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.00
1.00
像高[度]

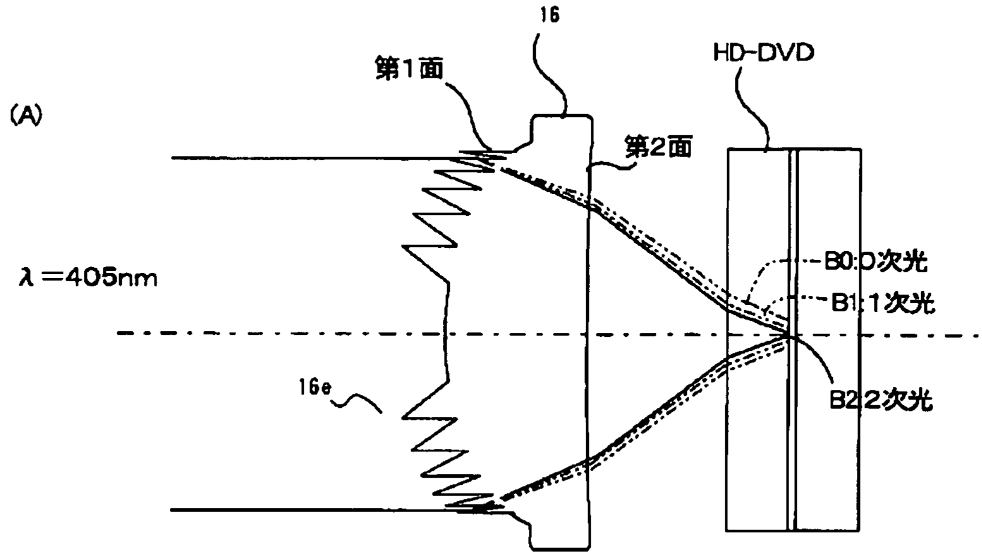
[Drawing 16]

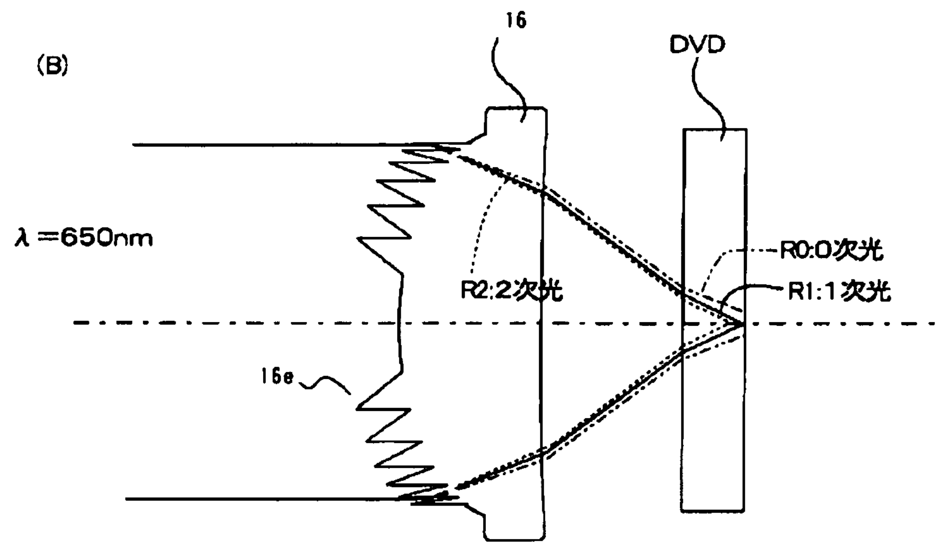

0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.640
0.660
波長(μm)

[Drawing 17]

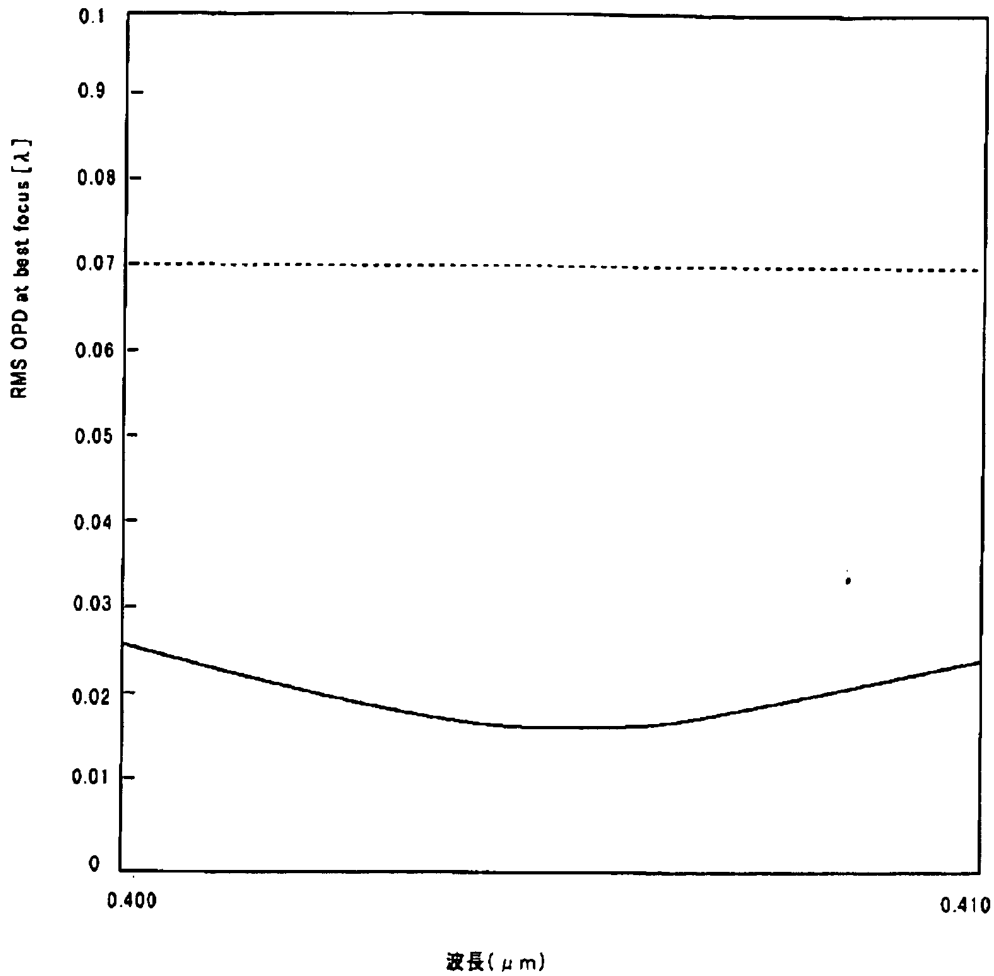

0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.00
1.00
像高[度]

[Drawing 18]

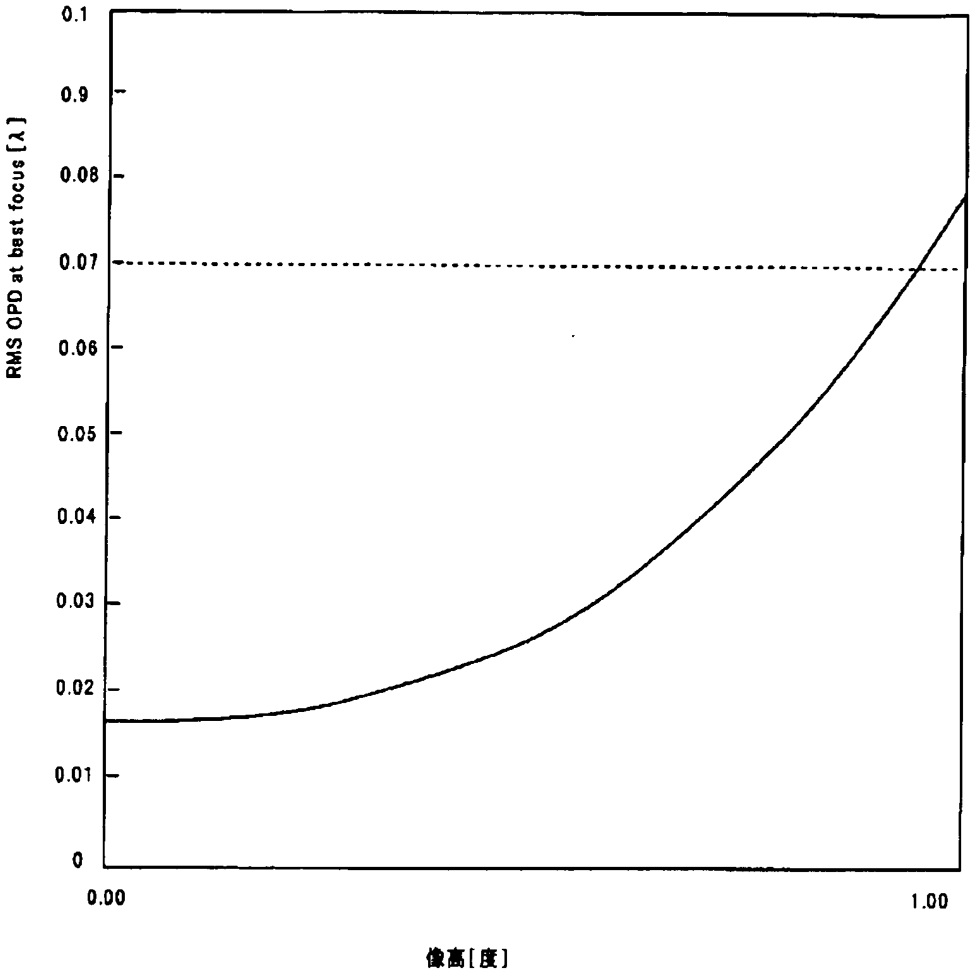

(A)
16
第1面
HD-DVD
第2面
λ=405nm
B0:0次光
B1:1次光
B2:2次光
16e


(B)
16
DVD
λ=650nm
R0:0次光
R1:1次光
R2:2次光
16e

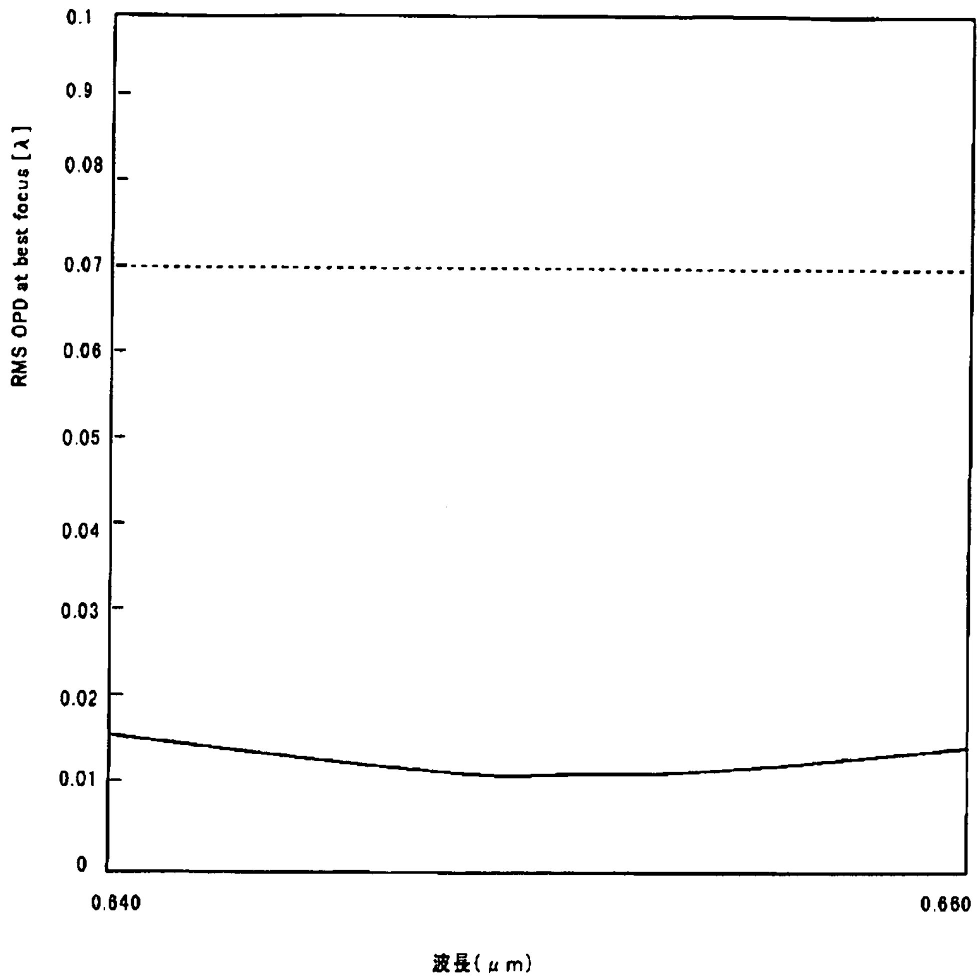
[Drawing 19]


RMS OPD at best focus [λ]
0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.400
0.410
波長(μm)

[Drawing 20]

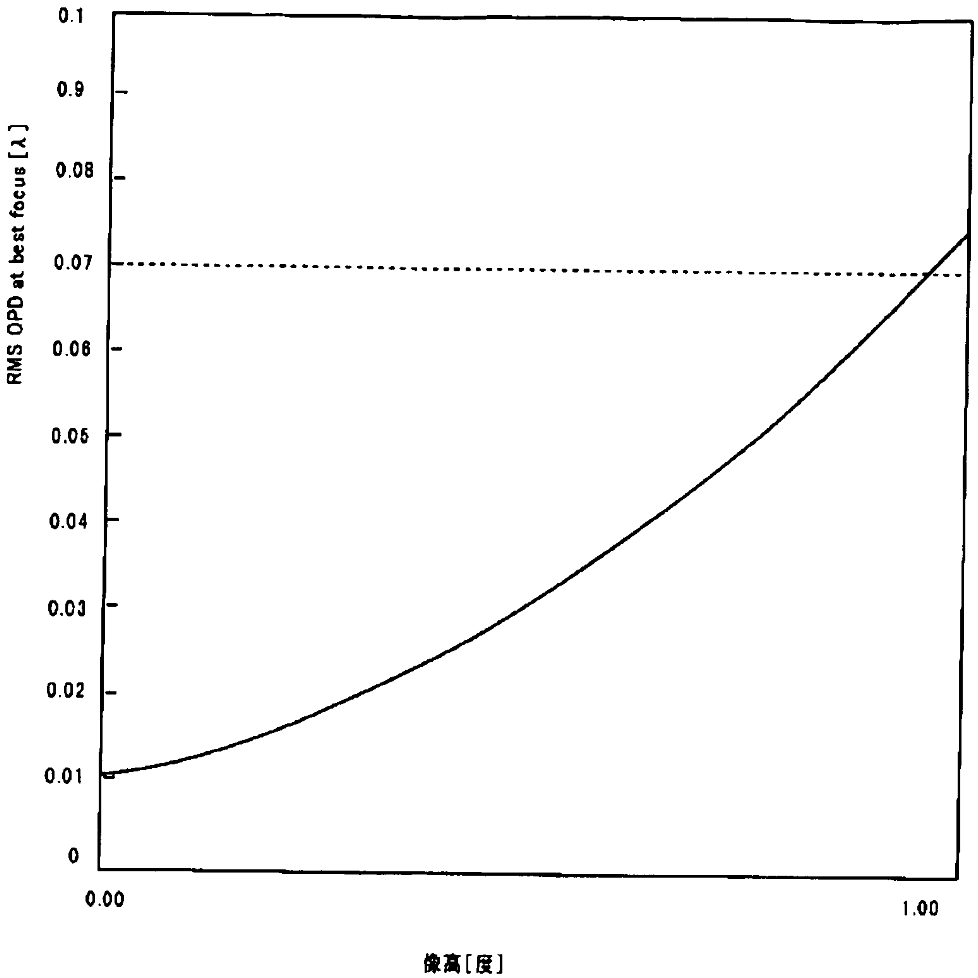

0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.00
1.00
像高[度]

[Drawing 21]



0.1
0.9
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
RMS OPD at best focus [λ]
0.640
0.660
波長(μm)

[Drawing 22]



[Translation done.]